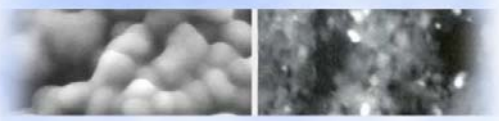
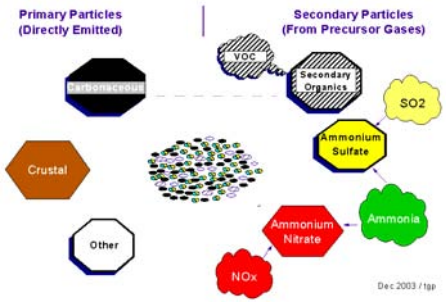
Preparation of Fine Particulate Emissions Inventories

Chapter 1 - PM $_{2.5}$ Overview



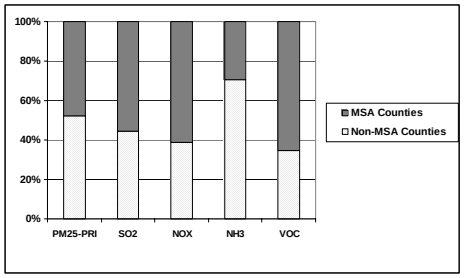
$PM_{2.5}$ In Ambient Air - A Complex Mixture



Urban PM Sites

- Eastern U.S. data is very homogenous
- Comprised mostly of carbon
- Ammonium and sulfate components combined are comparable to carbon
- Crustal component is very small

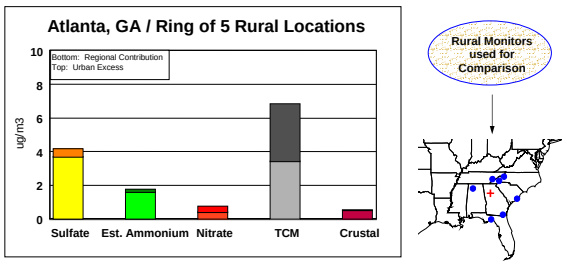
MSA to Non MSA Comparison of PM Emissions



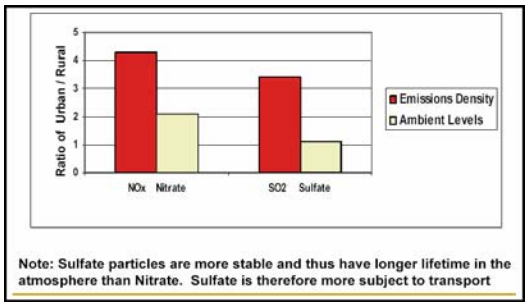
Comparison of Urban and Rural Data

- More sulfate than carbon in non-urban sites
- Sulfate concentration slightly higher in urban areas
- Carbon concentrations substantially higher in urban areas
- Conclusions
  - Sulfate is a regional problem
  - Carbon has a regional component with urban excess
- Urban Excess definition

Example of "Urban Excess"



Comparison of Urban~Rural Ratios



Note: Sulfate particles are more stable and thus have longer lifetime in the atmosphere than Nitrate. Sulfate is therefore more subject to transport

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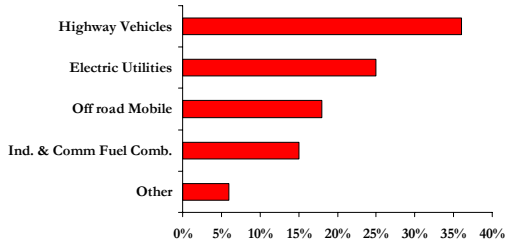
National NOx Emissions



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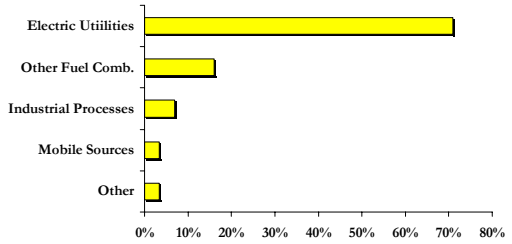
SO2 National Emissions



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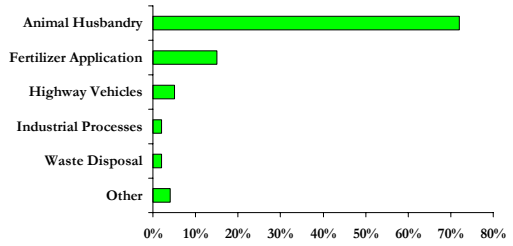
NH3 National Emissions



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Crustal Material

- Main Sources:
  - Unpaved roads
  - Agricultural tilling
  - Construction
  - Wind-blown dust
  - Fly ash (less significant)

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Crustal Material (cont.)

- Huge Disparity Between EI & Ambient Data
  - Ambient Data
    - < 1 ug/m3 in most of US
    - Exception: > 1 ug/m3 in much of Southwest
    - Emissions: 2.5M TPY (comparable to Carbon Emissions)

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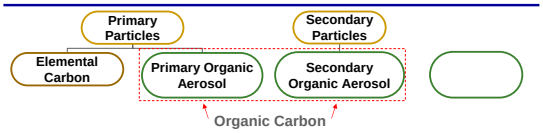
Crustal Material (cont.)

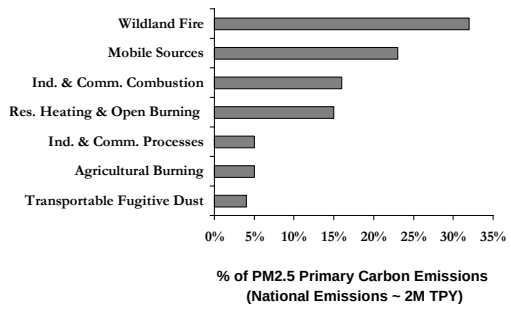
- Fugitive Dust has low "Transportable Fraction
- Crustal materials are a relatively small part of PM2.5 in the ambient air
- Fugitive dust is released near the ground and surface features often capture the dust near its source
- As much as 50-90% may be captured locally

Carbon Particles: Composition & Terminology



- Primary Particles
  - Elemental (Black) Carbon
  - Primary Organic Aerosol (POA)
  - Primary Carbon = EC (BC) + Primary Organic Aerosol (POA)

Primary Carbon in PM2.5



POA & EC Characteristics of Primary Carbon Emissions

Category	Ratio of organic carbon mass* to elemental carbon mass (average)	Potential range of ratios
Forest Fires	9.9	6 – 28
Managed Burning	12	6 – 28
Agricultural Burning	12	2.5 – 12
Open Burning - Debris	9.9	
Non-road Diesel Engines & Vehicles	**0.4**	**0.4 – 3**
On-road Diesel Vehicles	**0.4**	**0.4 – 3**
Trains, Ships, Planes	**0.4**	**0.4 – 25**
Non-road Gas Engines & Vehicles	14	0.25– 14
On-road Gas Vehicles	4.2	0.25 – 14
Fugitive Dust - Roads	22	3 – 65
Woodstoves	7.4	3 – 50
Fireplaces	7.4	3 – 50
Residential Heating - Other	26	
Commercial Cooking	111	13 – 111

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Primary Organic Aerosols (POA)

- Certain organic carbon excluded
- Organic carbon matter = primary organic aerosol (POA).
- The OC to POA multiplier for “fresh” POA in the emissions is usually estimated
- Particles “age” through oxidation.
- A different “multiplier” is applied to the POA by the chemical transport models to account for the “aging”

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Primary Organic Aerosols (cont.)

- Models only apply the additional multiplier to the POA, not the EC or SOA
- Multiplier is not related to the model’s estimate of secondary organic aerosol formed in the atmosphere from precursor gases
- Only accounts for further oxidation of primary particle emissions as the aerosol “ages”
- Transport models contain a separate module to simulate the amount of secondary organic carbon formed in the atmosphere from precursor

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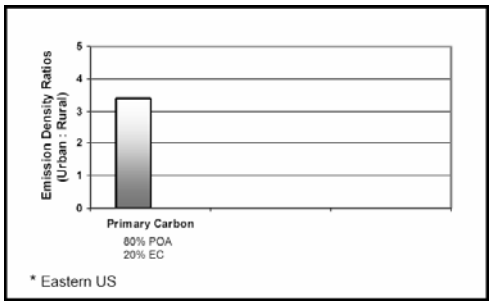
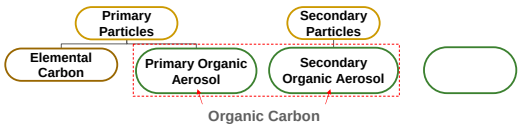
Primary Organic Aerosols (cont.)

- The derivation of a multiplier for ambient OC is much more complicated
- Use of a single multiplier introduces error
- A multiplier of 1.4 to 2.4 is often used for ambient data
- No agreed upon standard adjustment

Primary Carbon Emissions Emission Density Ratios



Carbon Particles: Composition & Terminology



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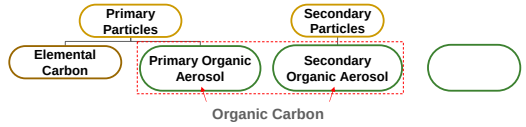
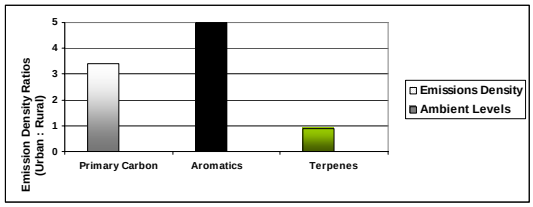
Carbon Particles: Composition & Terminology (cont.)



- Secondary Particles
  - Secondary Organic Aerosol (SOA)
- Organic Carbon = POA & Secondary Organic Aerosols

Comparison of Emission Density Ratios



	80% POA 20% EC	70% Mobile	Biogenic
Emissions:	**2.2M tpy (Ann)**	**3.7 M tpy (Ann)**	**.35 M tpy (July)**

* Eastern US

Summary of Important PM2.5 Source Categories

DIRECT EMISSIONS

Combustion [a, b]
- **Open Burning (all types)**
- **Non-Road & On-Road Mobile**
- **Residential Wood Burning**
- **Wildfires**
- Power Gen
- Boilers (Oil, Gas, Coal)
- Boilers (Wood)

Crustal / Metals [a]
- **Fugitive Dust**
- Mineral Prod Ind
- Ferrous Metals

PRECURSOR EMISSIONS

SO2 [c]
- **Power Gen (Coal)**
- **Boilers (Coal)**
- Power Gen (Oil)
- Boilers (Oil)
- Industrial Processes

NOx
- **On-Road Mobile (Gas, Diesel)**
- **Power Gen (Coal)**
- **Non-Road Mobile (Diesel)**
- **Boilers (Gas, Coal)**
- Residential (Gas, Oil)
- Industrial Processes

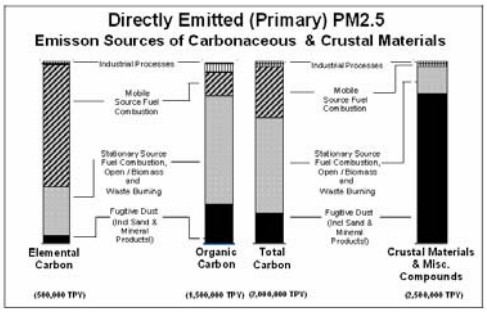
NH3
- **On-Road Mobile**
- **Animal Husbandry**
- **Fertilizer Application**
- Wastewater Treatment
- Boilers

VOC [d]
- **Biogenics**
- **Solvent use**
- **On-Road (Gas)**
- Storage and Transport
- Residential Wood
- Petrochemical Industry
- Waste Disposal

a Includes primary organic particles, elemental carbon and condensible organic particles; also some flyash
b Impact of carbonaceous emissions on ambient PM 5 to 10 times more than crustal emissions impact
c Includes SO2 and SO3and H2SO4 condensible inorganics
d Contributes to formation of secondary organic aerosols

NOTE: Categories in **BOLD** are most important nationally. Their relative importance varies among and between urban and rural areas.

PM2.5 Primary Emissions Sources - Summary



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